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ILLINOIS NATURAL HISTORY SURVEY

**Evaluating current reproductive success of lake trout
at the Port of Indiana breakwater**

Submitted to
US Fish and Wildlife Service

in partial fulfillment of the reporting requirements
for US Fish and Wildlife Service Project
Number 30181-2-J262

Center for Aquatic Ecology

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December 2005

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at the Port of Indiana breakwater**

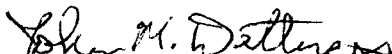
October 1, 2004 – November 30, 2005


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Background. Lake trout *Salvelinus namaycush* is the native top predator of Lake Michigan. It was extirpated from the lake by a combination of commercial overfishing and sea lamprey predation by the 1950s. Since then an aggressive program of stocking lake trout has been undertaken with the goal of establishing naturally self-sustaining populations of lake trout in Lake Michigan. Although this stocking program has built the population of adult lake trout to levels where substantial sport and commercial fisheries can be viable, no evidence of sustained natural reproduction has been documented in Lake Michigan.

The mechanisms that prevent establishment of reproducing stocks remain unclear. Current thinking centers on the possibility that adult stocks are not sufficiently high to spawn enough eggs to overcome the effects of egg and fry predators, many of which are exotic and have been introduced into the lake since 1960. In particular, there is concern that the exotic round goby *Neogobius melanostomus* can act as a more efficient egg predator than native sculpins. Alewife *Alosa pseudoharengus* also can prey on emerging lake trout fry (Krueger et al. 1995), potentially reducing recruitment success at this life stage if alewives are present over the spawning grounds when fry emerge.

With this background, it is important to note that the US Army Corps of Engineers (USACE) renovated the north and west break walls of the Port of Indiana during 1995-1996, including the addition of several small barrier reefs north of the breakwall to reduce wave energy impacting the breakwall itself. Lake trout spawned successfully there during 1992-1996, and lake trout fry were observed during 1993-1997 (Marsden and Chotkowski 2001). Since then, no research has been conducted at this site. During Fall 2001 assessments at the Port of Indiana, Indiana DNR personnel discovered about 18% of lake trout collected in their assessment nets were unclipped (69 of 361; B. Breidert, personal communication). This evidence strongly suggests that lake trout did reproduce at the Port of Indiana location, likely during the period when fresh cobble-sized stone was placed at the break wall and barrier reefs. The timing is such that we may now be seeing these first individuals returning to their hatching location as spawning adults.

Given this evidence of possible natural reproduction at the Port of Indiana, it is of critical importance to evaluate the condition of the substrate, the egg and fry predator density, the number of eggs and fry produced, the parental strain(s) of emerging fry, the average number of eggs and /or fry consumed by each predator, and the age and genetic structure of returning unmarked lake trout to determine whether the Port of Indiana still successfully produces lake trout. As a result, a detailed evaluation of the current habitat and spawning success of lake trout is needed to compare to work originally done during 1992-1997.

Methods

Study location. The Port of Indiana is located at the southern tip of Lake Michigan. We sampled three locations at the port, reflecting a gradient of zebra mussel density (Figure 1). A site along the west breakwall was heavily fouled by zebra mussels. A site along the north breakwall was largely unfouled by zebra mussels. A site along the submerged north breakwall reef was lightly fouled by zebra mussels. These sites were used in the sampling conducted by Chotkowski and Marsden (2001) during the mid 1990s.

Although the three sites exhibited a gradient of zebra mussel fouling intensity, round gobies were very abundant at all three locations.

Egg Deposition. We sampled for lake trout eggs at the three sites using a combination of two methods. We set gangs of 50 egg nets (Horns et al. 1989) at each site and also 8-10 egg bags (Perkins and Krueger 1994) at each site. Egg nets were deployed and retrieved by boat whereas egg bags were deployed and retrieved by divers. Net gangs were set on October 21, 2004 and retrieved on December 6, 2004. Egg bags were set on September 21, 2004 and retrieved on December 6, 2004. Upon retrieval, egg nets and bags were sorted by site in containers and returned to the laboratory where their contents were examined. Live eggs, dead eggs, and egg chorions were identified and enumerated. Round gobies and crayfish were identified and enumerated. All round gobies were measured (nearest 0.1 mm TL) and preserved for later diet analysis.

Fry Emergence. We deployed fry emergence traps consisting of a 51-cm-square base of angle iron with mesh sides tapering to a collection container on top (Marsden et al. 1988) by boat on April 4, 2005. The collection area under each trap was 0.26 m². Initially, 10 traps were set at each site. We then checked traps weekly until June 9, 2005, weather depending. Each week, all traps were lifted, checked for emergent fry or other fish, and redeployed.

Estimates of lake trout egg consumption. Based on our estimates of lake trout egg deposition, round goby density, and daily round goby egg consumption, we calculated the population-level consumption of lake trout eggs by round goby at the Port of Indiana during 2002-2004. Specifically, we employed estimates of lake trout egg deposition and of round goby predators from our egg bags expressed as density per m² of substrate. The mean number of lake trout eggs in round goby stomachs was estimated from stomach contents of round gobies recovered from egg bags. We also estimated the minimum size of a round goby capable of consuming a lake trout egg based on the smallest round goby that we observed with lake trout eggs in its stomach. Daily estimates of lake trout egg consumption by round goby were then calculated following the methodology of Chotkowski and Marsden (1999). Thus, the daily estimate of predation by round gobies on lake trout eggs can be expressed as:

$$P = D * p(e) * r,$$

where

P = Population consumption of lake trout eggs, expressed as number/m²/d

D = density of round gobies, number/m²

p(e) = the proportion of round gobies able to consume eggs,

r = the daily rate of lake trout egg consumption.

Taking this daily rate of lake trout egg consumption and dividing by the density of eggs deposited then provided the number of days that lake trout eggs could persist in the face of round goby predation.

We also calculated the lake trout egg: predator ratio as described by Fitzsimons et al. (2003). This index was developed to assess the likelihood that lake trout fry would emerge the following spring, given the number of egg predators available to feed on lake trout eggs throughout the winter. Based on sampling in lakes Michigan, Huron, and

Champlain, at ratio of at least 24:1 was deemed necessary to ensure fry emergence the following spring.

Results.

Egg Deposition. All 50 nets of the gang were retrieved from the north breakwall on December 6, 2004. Thirteen live lake trout eggs were recovered, along with 1 dead egg and 1 chorion. CPUE of lake trout eggs with this gear was 0.007 eggs/device/day. We recovered only one 21-mm round goby from these nets. Nine diver-deployed egg bags also were retrieved from this site on the same day. The bags held 79 live lake trout eggs, 6 dead eggs, and 15 chorions, yielding a CPUE of 0.15 eggs/device/day. Thirty nine round gobies ranging in size from 29 to 90 mm, along with three rusty crayfish *Orconectes rusticus* were also present in the bags.

The 50 egg nets collected from the north reef on December 6, 2004 yielded five lake trout eggs. No predators were recovered from this set of nets. CPUE of lake trout eggs with this device was 0.002 eggs/device/day. Eight diver-retrieved egg bags from this location on the same day produced 28 live lake trout eggs. CPUE from egg bags at this location was 0.05 eggs/device/day. Twenty three round gobies ranging in size from 36 to 122 mm, as well as 10 crayfish, were also present.

Egg nets collected from the west breakwall on December 6, 2004 yielded no live eggs, no dead eggs, and no egg chorions. CPUE for the egg nets was 0 eggs/device/day. This gang of 50 nets contained one crayfish. Nine diver-retrieved egg bags from the same location generated 98 live lake trout eggs, 25 dead lake trout eggs, and 8 egg chorions. CPUE from the egg bags at this site was 0.19 eggs/device/day. Twenty five round gobies ranging in size from 31 to 162 mm, plus 3 crayfish, were also retrieved from the egg bags.

Fry Emergence. One emergent lake trout fry was collected during spring 2005. Several small round gobies were collected in the traps. We have preserved their stomachs to examine whether any lake trout fry were present in round goby stomachs.

Lake trout egg predation. Round gobies were generally dense at all sites at the Port of Indiana (Figure 2), with densities most often between 30 and 35 individuals/m². Round gobies smaller than 50 mm did not consume lake trout eggs in the field. Hence, we used this size as the smallest size at which round gobies could consume lake trout eggs. The size distribution of round gobies varied among our three sampling locations, with the west wall having the largest round gobies (Figure 3). Along the north wall, about 60% of the round gobies collected were too small to consume lake trout eggs. About 40% of round gobies at the north reef also were too small to consume lake trout eggs. Conversely, only 4% of round gobies along the west wall could not consume lake trout eggs.

Rates of egg deposition by adult lake trout varied substantially across sites and years (Figure 4). Generally, egg deposition rates were lowest at the north reef and highest along the west wall. Egg deposition ranged between 10 and 509 eggs/m², and averaged 139 eggs/m² across sites and years.

Daily consumption of lake trout eggs was about one lake trout egg per goby. Expanding this by the density of round gobies able to consume eggs, consumption of lake

trout eggs by round gobies was generally between 15 and 20 eggs/m²/d across sites and years (Figure 5). However, as many as 57 eggs/m²/d were consumed by round gobies along the west wall in 2004. Given this daily rate of egg consumption, round gobies could consume all lake trout eggs deposited in less than 30 days, and often in less than 10 days.

The lake trout egg: predator ratio also was extremely low across most sites and years (Figure 6). Only along the west wall in 2003 did the ratio exceed 24:1 (at 65:1). All other ratios were < 5:1, indicating that round gobies were extremely abundant relative to the density of lake trout eggs deposited.

Discussion.

During 2004, densities of lake trout eggs collected by egg bags were at least an order of magnitude greater than the densities collected by egg nets. We agree with Marsden and Chotkowski (2001) that egg bags are a much more efficient sampler of lake trout eggs.

Although the round gobies present in fry traps were too small to consume lake trout fry, this does not mean that round gobies do not feed on newly emerged lake trout fry. In fact, it is quite likely that round gobies can feed on lake trout fry while they are in the cobble substrate.

Although egg deposition rates as measured by egg bags have not changed substantially since the mid-1990s, fry emergence rates have plummeted. We collected 1 emergent lake trout fry during spring 2003, none during spring 2004, and 1 during spring 2005. Given our more extensive trap effort than was consistently used during the mid-1990s (Marsden and Chotkowski 2001), it is worrisome that our number of emergent fry is among the lowest observed during the mid 1990s. Harsh weather conditions during spring 2005 resulted in the loss of over 50% of our fry traps. Because our sampling effort was much reduced in 2005, we believe another season of capturing fry is necessary to verify this trend of very few fry emerging. Additional sampling at this site throughout the remainder of the project will help to refine our conclusion that round gobies are strongly negatively affecting survival of lake trout eggs.

Round gobies constitute a significant new threat to successful lake trout reproduction through predation on eggs and newly hatched fry. They are very abundant as compared to native predators such as mottled sculpin *Cottus bairdi* and crayfish *Orconectes* spp. We documented substantial numbers of round gobies in both egg nets and egg bags. However, our estimates of number of round gobies in egg bags is certainly an underestimate because many round gobies escaped from the bags while divers were removing bags from the substrate. An accurate count of the number of round gobies escaping from each bag could not be made because of poor visibility. However, divers could regularly see and feel round gobies escaping from the bags. Nevertheless, lake trout egg deposition rates did not appear to be substantially different from those reported by Marsden and Chotkowski (2001), especially for egg bags. CPUEs for egg nets were at least an order of magnitude lower in 2003 and 2004 than for 1993-1996 (Marsden and Chotkowski 2001). However egg nets are not thought to be completely representative of egg deposition rates owing to the likelihood that some nets would not land face-up and that wave action could displace several members of each net gang. When looking at

CPUEs for egg bags, however, deposition rates in 2003 and 2004 were within the range of those reported during 1994-1996 (Marsden and Chotkowski 2001).

Because round gobies are such voracious predators, even at relatively cold water temperatures of 5 °C, they exert tremendous predation pressure on lake trout eggs. Our calculations indicate that even when egg deposition rates exceed 500 eggs/m², the existing density of round gobies could eliminate those eggs within 30 days. These numbers are telling because the egg deposition rates seen by us at the Port of Indiana are among the highest seen in all of Lake Michigan (Fitzsimons et al. 2003). Hence, if round gobies consume almost all lake trout eggs before hatching at the Port of Indiana, this bodes extremely poorly for other lake trout spawning reefs where round gobies are or will be present. Within the next decade it may be that the only spawning areas without substantial round goby populations will be offshore reef locations such as the mid-lake reef complex or Julian's Reef. As a result, it is very likely that managers will need to take into consideration round goby expansion as they formulate successive versions of the lake trout rehabilitation plan.

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Figure 1. Location of sampling sites at the Port of Indiana breakwall during 2002- 2005.

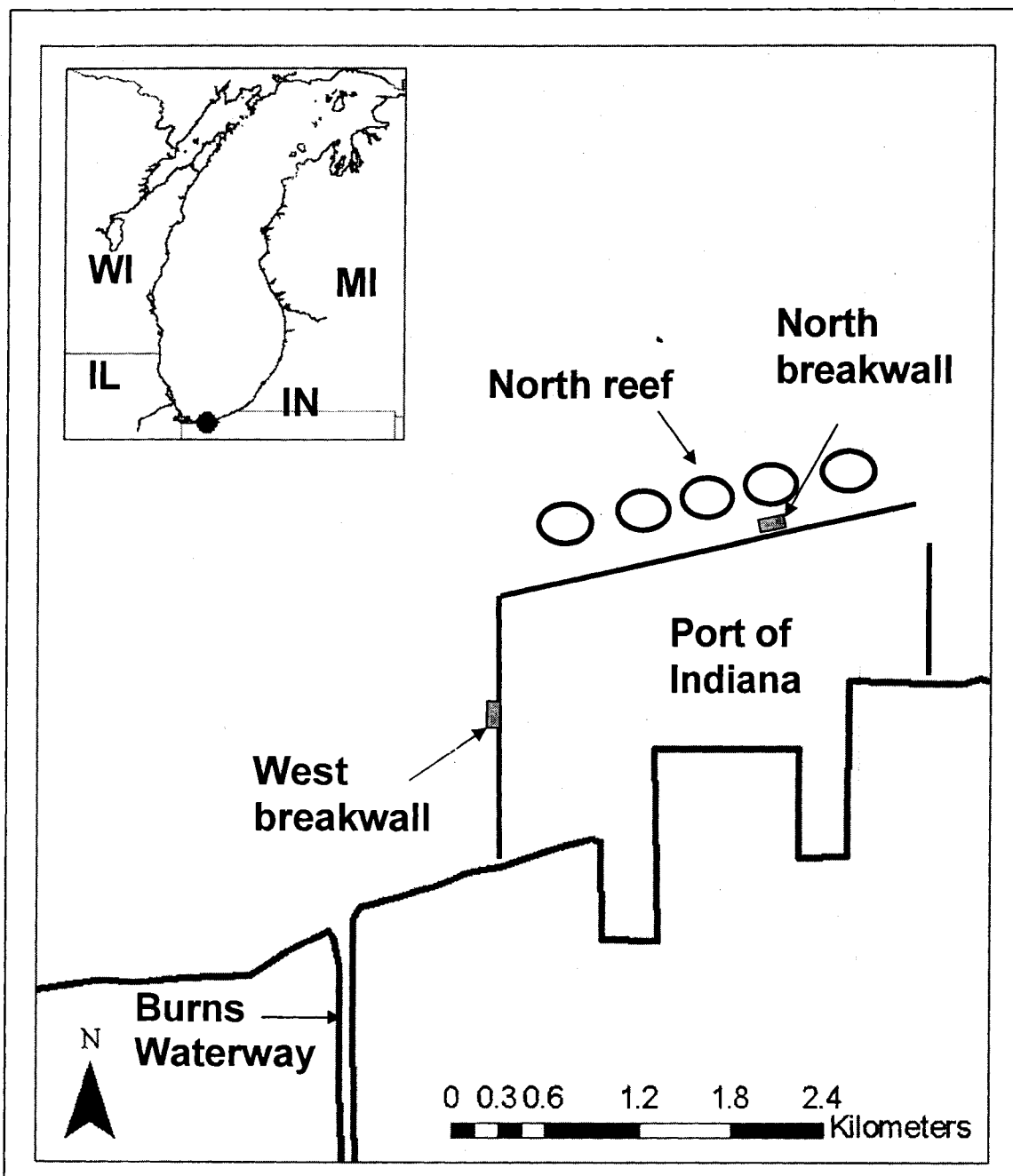


Figure 2. Estimated densities of round gobies collected from egg bags retrieved during December 2002-2004 at our three sampling locations at the Port of Indiana.

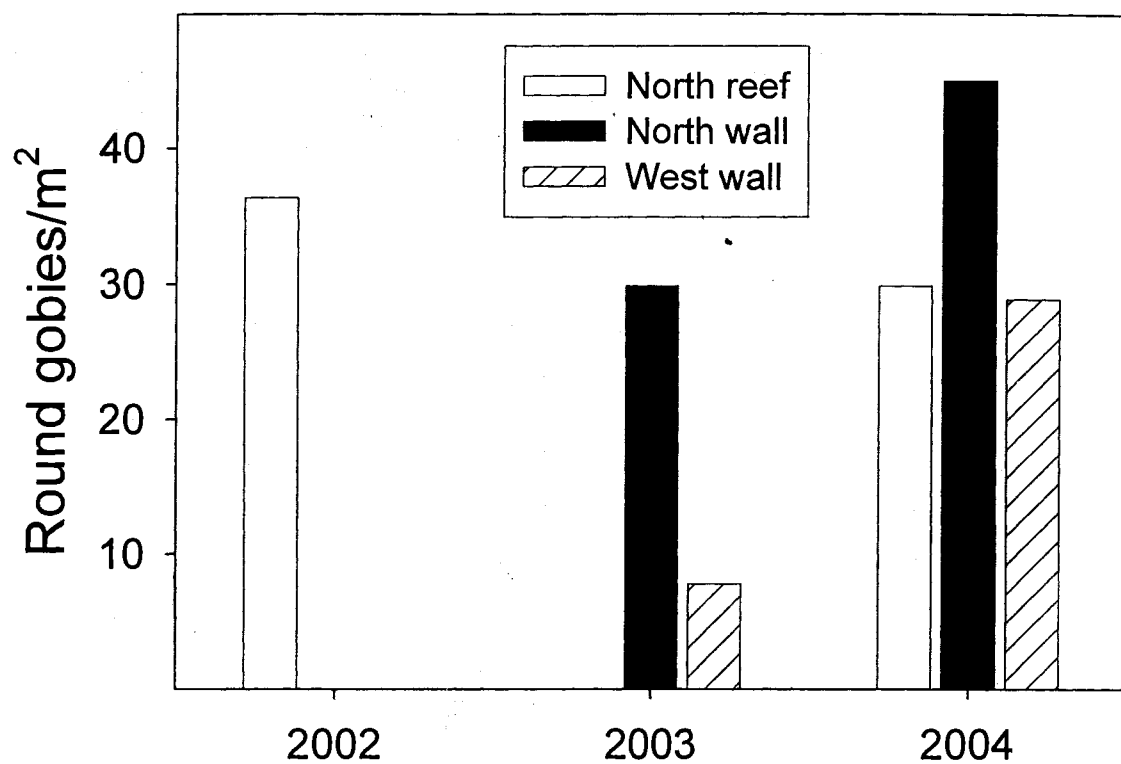


Figure 3. Percent occurrence of round gobies partitioned into 10-mm length bins. Round gobies were collected from egg bags during December 2002-2004 along the three sampling locations at the Port of Indiana

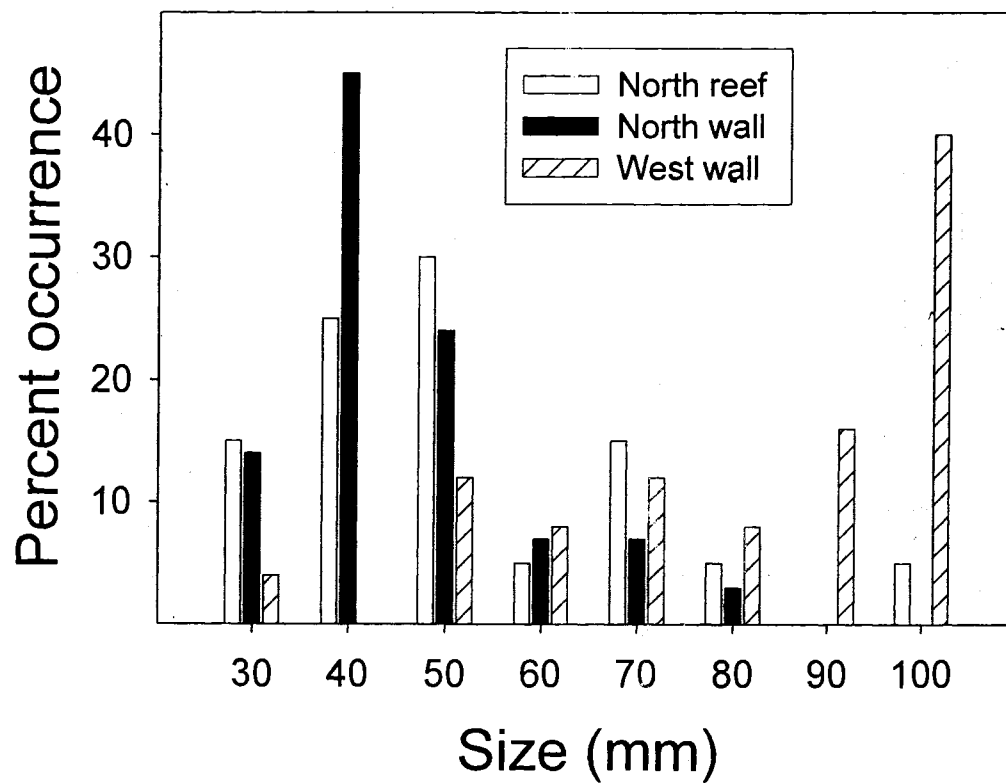


Figure 4. Lake trout egg deposition (eggs/m²) at three sites along the Port of Indiana breakwall during fall 2002-2004.

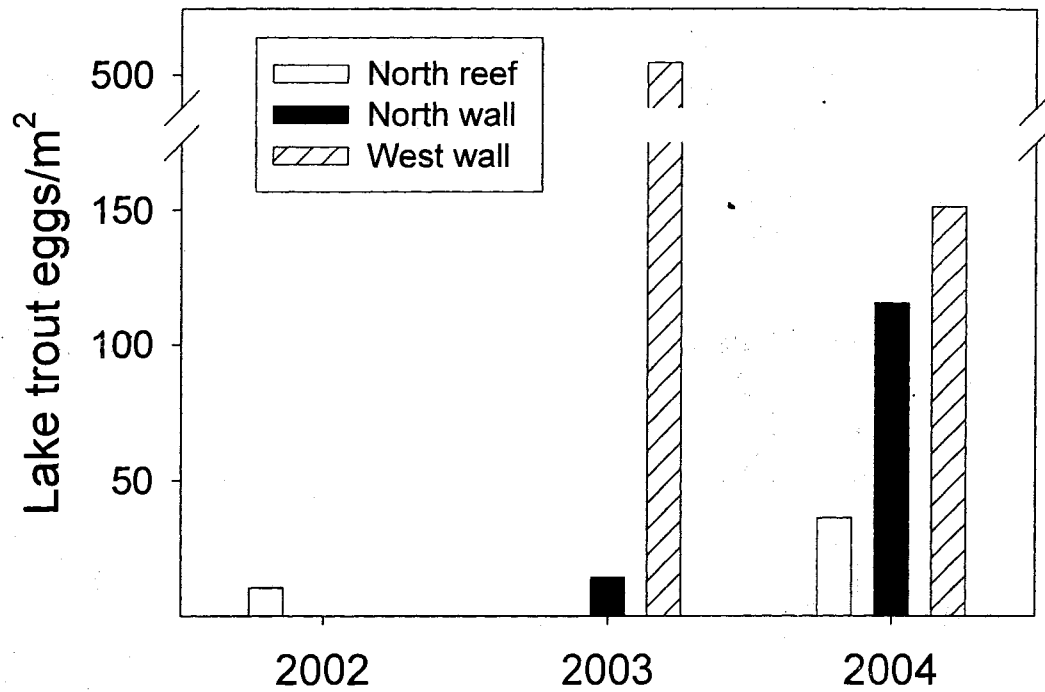


Figure 5. Estimated number of lake trout eggs consumed/m²/d by the round goby population large enough to consume lake trout eggs. Estimates are for the north wall, north reef, and west wall of the Port of Indiana during fall 2002-2004. LAT = lake trout.

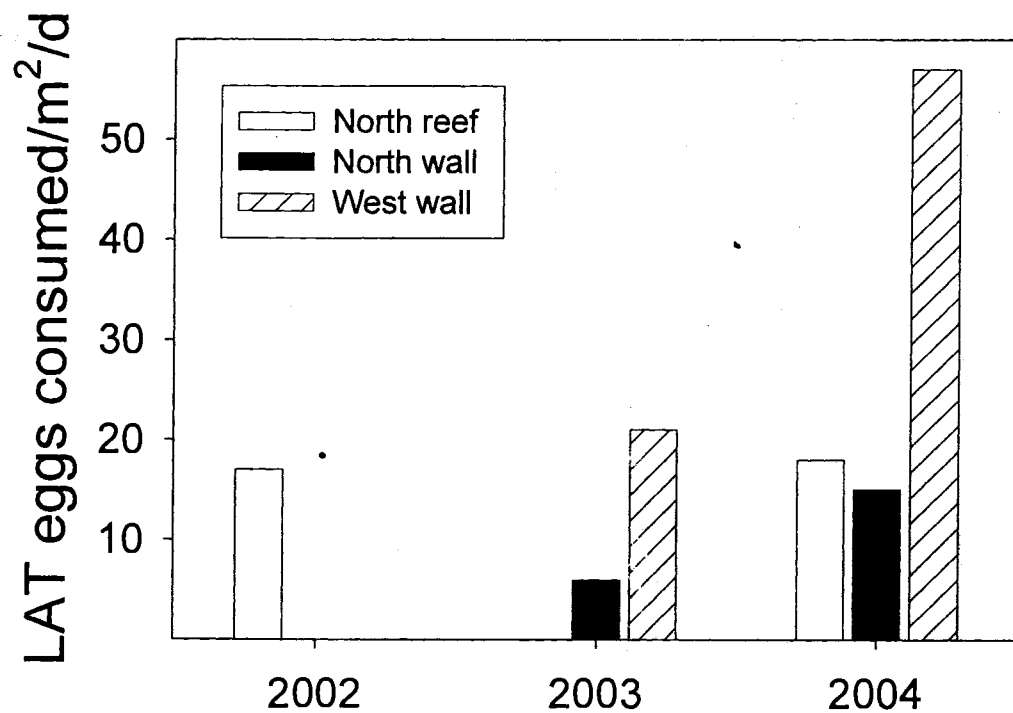


Figure 6. The lake trout egg: egg predator ratio at the north reef, north wall, and west wall of the Port of Indiana during fall 2002-2004. An egg: predator ratio of 24:1 is considered necessary to ensure emergence of fry the following spring.

